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INVESTIGATING METAL TECHNOLOGY IN A SETTLEMENT. THE CASE OF AKROTIRI AT THERA*

To Agnes Sakellariou
In Memoriam

The first question posed by an archaeologist dealing with the problem of whether Metal Technology was practised in a settlement or not, is whether any metal artifacts were found there. Though this is the reasonable question, one is actually starting from the end of a long process, that is from the final product itself. Nevertheless, we shall start at the end:

SUBJECT 1: The Products of Metal Technology

Artifacts made of metal were valuable in ancient times, due to both their material and their function, which could be either purely practical or contribute to the owner's prestige.

For this reason the discovery of hoards of used metal objects is not rare[1] and such discoveries point to an accumulation of wealth, as these objects could be remelted any time and re-cast to form new ones. The opposite, that is the absence or the scarcity of metal finds in a site, is also common, but it normally indicates that the items have been removed by either the inhabitants or plunderers, again for the same reason: their value. So, the questions that follow refer to the quantity of metal finds and to their distribution in a specific site.

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1. See for instance K. BRANIGAN, Early Aegean Hoards of Metalwork, *BSA* 64, 1969, 7, C. RENFREW, *The Emergence of Civilisation*, London 1972, 305-328, B. KNAPP, J. D. MUHLY, P. M. MUHLY, To Hoard Is Human: Late Bronze Age Metal Deposits in Cyprus and the Aegean. *RDAC* 1988, 233-262.

1.1. The quantity of metal finds.

How many items made of metal do we expect to find while excavating a settlement? The answer is of course related to parameters such as the date of the culture we are dealing with; in a settlement of «urban» character, like the Late Cycladic city at Akrotiri[2], the discovery of metal items is expected; it is the contrary that requires an explanation. Furthermore, since the pumice and ash ejected by the volcano sealed the setlement's last occupation level, there have been no major disturbances in the archaeological record, by either nature or man. So, the quantity of equipment found is closer to the original amount used in the settlement. Of course, there remains the factor of the inhabitants' behaviour during the abandonment of the city, with the possibility that some «valuables» or «personal items» were selected and taken, while others were left behind. There is the additional element of metal deretioration, as well as the fundamental question of how many of the objects found should be considered as having been «in use» at the actual find spot and how many could have found their way through various formation processes[3].

At Akrotiri, we may assume that what is found is actually what was left behind and the archaeological record may be used as an example for other sites with less favourable conditions of preservation. Also, the majority of the metal artifacts belong to the settlement's last phase of life, which is chronologically defined by two destructions: the seismic destruction at the beginning of LMI A and the volcanic destruction before the end of the same period[4]. We know that after the first destruction the town was rebuilt on a vast scale[5]. So, regardless of their date of manufacture, the objects found were in use during the last phase of the town's life[6].

What was left behind does not look promising. The quantity and range of metal artifacts seem to be small compared to the general amount of the settlement's equipment. Supposing the inhabitants' behaviour was the same during the abandonment of the settlement, the objects they preferred to take

2. DOUMAS = C. DOUMAS, *Thera, Pompeii of the ancient Aegean*. London 1983, 45.
3. M. B. SCHIFFER, Towards the Indentification of Formation Processes, *American Antiquity* 48, 1983, 675-706.
4. M. MARTHARI, The Chronology of the Last phases of Occupation at Akrotiri in the Light of the Evidence from the West House Pottery Groups, in D. A. HARDY et al. (eds), *Thera and the Aegean World III*, 1990, vol. 3, 67, Table 1.
5. DOUMAS, 45, C. PALYVOU, The Destruction of the town at Akrotiri, Thera, at the beginning of LC I: Rebuilding activities, in J.A. MACGILIVRAY-R. BARBER (eds), *The prehistoric Cyclades*, Edinburgh 1984, 134-147.
6. With the possible exception of finds beneath the floors or in some very special cases such as an Early Cycladic dagger found in the area where the Early Cycladic figurines were also found: *Ergon* 1992, 78-80.

away with them would be much the same; in that case, could we infer that since no gold jewellery has been found (with only two tiny exceptions up to now) all took their jewellery away? But did all own gold jewellery? We do know that jewellery made of other materials (e.g. bronze, silver, rock crystal etc.) existed, since some silver rings, bronze pins and a rock crystal pin head have been found[7], and we also have the indirect evidence supplied by their representations in art[8]. Of the bronze implements, there are those actually found in the settlement[9] and those detected by indirect evidence such as traces of their use on other materials (e.g. on stones) or their accessories made of other materials (e.g. bone handles of bronze awls). Indirect evidence is also provided by the mere existence of other technologies requiring metal tools[10], also by their representations in pictorial art[11]. Bronze vessels were found at Akrotiri[12] but not in every house. Does this mean that not every household possessed them or does it only indicate a difference in abandoning behaviour, some inhabitants having taken them away, others having left them behind, or even hidden them? And so we come to the next question:

1.2. The distribution of metal finds in the settlement

Were metal items –regardless of number– at least present in every building? The mere presence of metal finds is attested in all sectors of the Akrotiri settlement. Indeed, not only every building, but almost every house has yielded some metal objects; in Sector Delta, for instance, all four houses of this building complex[13] had metal objects among their equipment. The large building of Xestè 3, though almost completely excavated, has given

7. *THERA I-VII* = S. Marinatos, *Excavations at Thera*, Athens 1968-1976. *THERA V*, pls 77β, 78α, *THERA VII*, pl. 57b.
8. Χ. Τελεβαντου, Κοσμήματα από την προϊστορική Θήρα, *AE* 1984, 19 κ.ε., I. Tzachili, Of Earrings, Swallows and Theran Ladies, in A. Bonanno (ed), *Archaeology and Fertility Cult in the Ancient Mediterranean*, Malta 1986, 97.
9. Doumas 114-116.
10. E. g. the manufacture of stone vessels, cf. P. Warren, The stone vessels from the Bronze Age Settlement at Akrotiri, Thera, *AE* 1979, 103, or the building construction, cf. K. Παλυβου, *Ακρωτήρι Θήρας: Οικοδομική τέχνη και μορφολογικά στοιχεία στην Υστερο-κυκλαδική αρχιτεκτονική* (διδακτορική διατριβή Εθνικού Μετσοβίου Πολυτεχνείου) Αθήνα 1988, 360 κ.ε.
11. E. g. swords and daggers depicted on frescoes, cf. L. Morgan, *The Miniature Wall Paintings of Thera: A study in Aegean Culture and Iconography*, Cambridge 1988, 105.
12. Doumas 115, H. Matthaeus, *Die Bronze-gefässe der kretisch-mykenischen Kultur, PB II*, München 1980, 13-14.
13. Cf. A. Μιχαηλιλιου, *Ακρωτήρι Θήρας: Η μελέτη των ορόφων στα σπίτια του οικισμού* (διδακτορική διατριβή Πανεπιστημίου Θεσσαλονίκης) 1991, εικ. 86.

fewer metal objects compared to the smaller houses of Sector Delta, though it seems that it was richer in luxury items, such as stone vases and lamps. Could it be that its wealth once extended to more precious metal artifacts[14] that were for this reason taken away? It would be interesting to compare the contents of houses of equal standard; the picture that emerges from such a comparison between five houses –the four of Complex Delta (not fully excavated) and the West House (almost completely excavated)– is the following:

1. The House with rooms Delta 1, Delta 9, Delta 9.1 and Delta 9a-e

Lead weights, bronze balance pans, bronze pin, gold cover of a bead, bronze tools, bronze bands.

2. The House with rooms Delta 16, Delta 10-13, Delta 15

Lead weight, lead sheet and rivets, bronze balance pans, bronze pins or needles, silver rings, bronze hooks, bronze fittings, bronze vessels.

3. The House with rooms Delta 2, Delta 18, Delta 19, Delta 21

Lead weight(s), bronze hooks, sickles, awls and chisel, bronze vessels, bronze daggers.

4. The House with rooms Delta 3, Delta 4, Delta 5, Delta 7, Delta 8, Delta 8a, Delta 17, Delta 17a.

Lead weights, bronze pin(?), tweezers(?) and double-edged knife (razor?), bronze hooks, saw and chisel, bronze fittings, bronze vessels, bronze dagger.

5. The West House

Lead weights, bronze awl and saw, bronze one-edged and two-edged knives, bronze vessels.

If we follow Catling's classification of metal items into vessels, weapons, tools, objects of personal use, fittings and statuettes[15], or Branigan's into

14. See for instance the representations of vessels and jewellery on the building's frescoes: Χ. Ντουμας, *Οι τοιχογραφίες της Θήρας*, Αθήνα 1992, 136-171.
15. H. W. Catling, The Bronzes and Metalworking Equipment, in M. Popham et al. (eds), *The Minoan Unexplored Mansion at Knossos*, London 1984, 208-220.

vessels, weapons, tools, toilet implements, jewellery, other implements, figurines and miscellaneous groups[16], we have of course to decide if some items -hooks for instance- belong to the broad collection of «tools» (as in Catling's classification), or in the general category of «other implements» (as in Branigan's classifation); if daggers should only be classified under weapons, though they were probably also part of the personal belongings; if knives are primary tools or if double-edged knives should be all called, on typological grounds, «razors», therefore «personal belongings» as well, etc. Even so, we may summarize that the metal items found in the above houses are mainly: a) lead weights, b) bronze tools, c) few metal objects of personal use d) bronze vessels and e) some relics of bronze fittings. So the above equipment could have been common in households of the settlement. From this point, however, diversity begins. It may be proved by further investigation that every house at Akrotiri had lead weights (Pl. 22a). On the other hand, it is expected that tools may not have been the same in every house: sickles, for instance, may not have been necessary to the inhabitants of Xestè 3 and up to now sickles have been identified in two areas of the settlement: three in Sector Alpha and three in Room Delta 2 with the surrounding area[17]. Also, though vessels have been found in both the West House and the House Delta 3... Delta 17a, in the second case the amount was greater and some vessels were found stored in a room as if forming a «hoard»[18]. So other questions arise, requiring further research in more specific fields: was there any preference for a certain object in some areas of the settlement and could this be explained in terms of a broad or limited use, in terms of social organization, in terms of selection during the evacuation of the settlement? We must also decide whether an object found inside a house was actually *in situ*. Even when we have reached the conclusion that the specific object belonged to the specific house (and even more precisely to a certain room or storey), we will have to decide whether it was in use in this house (whether in action or stored) or whether it was left there accidentally or intentionally. Nevertheless a very preliminary discussion on Subject 1 (the products of metal technology at Akrotiri) has led to a picture of the metal equipment of the average household of the settlement, and it seems that weapons are not a very common find in them. In fact, apart from the one-edged knife, which should rather be classified under the general category of «tools», the only type of weapon recorded up to now is the dagger, with some samples found in the settlement (Pl. 22b). So, were weapons part of the personal belongings that the inhabitants took away with them? This is one

16. K. Branigan, *Aegean Metalwork of the Early and Middle Bronze Age*, Oxford 1974, 197.
17. *THERA II*, fig. 29, *THERA IV*, pls 38A, 89β.
18. *THERA IV*, pl. 23α.

of the reasons why weapons often follow their owners to their graves, but no tombs have yet been excavated at Akrotiri.

SUBJECT 2. The Technology of Metal-Working

The products themselves are the proof of the mode of their manufacture. So there is ample evidence for the technologies of sheet metalworking (provided for instance by the vessels) or of casting (provided by many tools). But were these technologies practised *in situ*? Manufactured items could be brought from elsewhere and though in an urban settlement metalworking is one of the technologies expected to have been applied, the stage of its development may vary, from a limited action to meet a community's needs to a skilled industry for mass production of luxury items, possibly intended to satisfy the demands of an external market too. From this aspect some products may be considered as imports, in terms of their style or the special technology involved in their manufacture; for example, what could we say about a dagger possibly found in Thera, which is inlaid in the technique of «peinture en métal», that flourished in the Peloponnese[19]? Many bronze vessels found in Thera may have a «Minoan character»[20] but sometimes estimations in terms of style may be based on pre-conceived ideas and in any case there remains the difficulty of discriminating between actual imports and local imitations, especially when it comes to metal objects; provenance studies of the raw material of which artifacts were made are of certain value, but there is always the chance that the raw material and not the artifact was imported, or that the object in question was made of re-cycled material. And we have to bear in mind that over a considerable area (in the Aegean anyway), a certain vogue developed in most fields of art[21]. Regardless of the provenance of the raw material, or even the strict nationality of the craftsman, what interests us here is on what grounds can we decide that metallurgy was practised in the island itself. On what grounds can we be sure that metalworking was practised in the settlement itself.

«There is no doubt that the whole process of bronze and silver-lead working, from the mining of the ore to the production of finished objects,

19. A. Xenaki-Sakellariou, C. Chatziliou, *«Peinture en Métal» à l'époque mycénienne*, Athènes 1989, 14, 17.

20. H. W. Catling - R. Jones, Analyses of Copper and Bronze Artefacts from the Unexplored Mansion, Knossos, *Archaeometry* 19, 1, 1977, 58.

21. See for instance C. Doumas, Conceptions artistiques à Théra et dans la Mediterranée orientale à l'époque préhistorique, in P. Darque - J. C. Poursat (eds). *L'iconographie minoenne*, *BCH* Suppl. 11, Paris 1985, 33.

took place in the Cyclades from EC II and probably earlier»[22] and there is no objection to the Early Cycladic tradition in metalworking[23]. Still it would be useful to recall any direct evidence of metalworking activity in Late Cycladic Akrotiri:

No furnaces have yet been found. Of course, we would not expect them inside the settlement, at least these intended for smelting the ores. Their probable position should be either near the mines, if any[24], or in places with ample fuel supplies. Many pieces of raw material from the Akrotiri settlement that were originally recorded as slags (e.g. Pl. 24c), have been proved to be just material erupted by the volcano[25]. A furnace of some sort should be needed to simply melt metal in a crucible, but if it was without lining fit would leave little trace in the archaeological record[26]. Some hearths belong to the built-in equipments of groundfloors in some houses (Rooms Delta 1a, Alpha 1, etc.), but there is no secure evidence relating them to metal working activities, and the so called «Workshop, possibly of coppersmiths» in sector Gamma[27] has not yet been fully excavated.

Of crucibles, a fragment of the bowl with some metal «slagging» visible in the interior (Pl. 23a) has been found. Such vessels were made «to meet the needs of the metalworker to melt and combine materials under controlled conditions, to carry the molten metal and pour it into moulds»[28]. The exterior is clear, as Davey thinks proper for coppermelting crucibles, where instead of a furnace placing under them, forced ventilation was directed at the charcoal placed over the metal in the crucible[29]. And the metal waste in the interior includes copper. The vessel would be hand made with thick walls and the clay should have inclusions, all the above being necessary properties in order to withstand the high temperatures[30]. A slag analysis and an investigation of the composition of the clay should be the next steps, before

22. R. Barber, *The Cyclades in the Bronze Age*, London 1987, 112.
23. Cf. X. Τσουντας, Κυκλαδικά, *AE* 1899, 123-4. C. Renfrew, *Supra* n. 1, 308 ff., X. Ντουμας, Τα νησιά και η πρώιμη μεταλλουργία στο Αιγαίο, Ίδρυμα Ν. Μ. Γουλανδρή, *«Διαλέξεις 1986-1989»*, 111-116.
24. Cf. K. Branigan, *supra* n. 16, 68.
25. Personal comunication with the geochemist W. M. Murphy of the Centre for Nuclear Waste Regulatory Analyses, San Antonio, Texas, and the chemical engineer N. Beloghiannis, Institute of Stone, Athens. I thank them both for their help on this matter.
26. R. F. Tylecote, *The Early History of Metallurgy in Europe*, New York 1987, 181.
27. *THERA III*, 43-44.
28. R. D. G. Evely, *Minoan Crafts, Tools and Techniques. SIMA* XCII: 2, Göteborg (in press). I am indebted to Dr Evely for the permission to consult the manuscript and cite the references that follow.
29. C. J. Davey, Crucibles in the Petrie Collection and Hieroglyphic Ideograms for Metal, *JEA* 71, 1985, 142, 144.
30. For all the details on this subjet cf. R. D. G. Evely, *supra* n. 28.

saying anything further. Unfortunately we do not have a good picture for its context; it was found outside the NE corner of the House of the Ladies, but while excavating only in depth for one of the wells needed for the pillars to support the modern roof of the site[31]. The fragment's length is 7 cm.

Air supply was often directed to the crucible via blowpipes[32] and it seems that two clay objects from Akrotiri (one almost complete) could be the tuyères from blowpipes (Pl. 23b). They are not of the conical type[33] and, though the view is that, since a smith's tuyère lasted longer than the smelting ones, considerable care was put into making them[34], these are both rougher in shape. But they look very much like the Egyptian ones[35]. And since they are rather small, they were probably meant for small-scale activity.

Ancient stone moulds provide the earliest evidence for the concept of mass production[36]. So far only one steatite mould has been found at Akrotiri (Pl. 24b) and presumably not for making jewellery, weapons or tools. It is an open/single mould of Evely's Type 1a[37], with the two opposite faces carrying matrices which I believe were meant to produce ingots of a shape known from various places[38]. Steatite is an ideal material for making moulds, as it is resistant to heat shock and easy to carve[39]. An X-Ray fluorescence spectometry (by Dr Paradelis in Demokritos Laboratory) has helped Dr Bassiakos to reach some conclusions which he kindly communicated to me: Trace elements of Fe, Ni and Cr were found, completely in accordance with the mould's material (the steatite). But the presence of Pb in the interiors of the matrices (while not in other parts of the block), indicates that lead had been poured into this mould. If indeed lead ingots were produced in this mould, it was not a valuable object to be taken away. We know, for instance, that moulds were usually taken by the artist when he travelled abroad[40]. There is even the literary evidence, that when the city of Aratta was besieged by the

31. In well 99: *THERA V*, 8.
32. See Egyptian melters with blowpipes in B. SCHEEL, Egyptian Metalworking and Tools, *Shire Egyptology* 13 1989, 22-25.
33. Like e. g. Poliochni's: L. BERNABO-BREA, *Poliochni, Città preistorica nell' isola di Lemnos*, I, 1964, 589, tav. LXXXIII. They do not resemble also the tuyères from Palaikastro: S. HEMINGUAY, *BSA* 87, 1992, 144-145.
34. R. F. TYLECOTE, *supra* n. 26, 123.
35. B. SCHEEL, *supra* n. 32, fig. 15, 22, 30-32.
36. M. J. BECKER, Sardinian Stone Moulds: An Indirect Means of EvaluatingBronze Age Metallurgical Technology, in BALMUTH-ROWLANDS (eds), *Studies in Sardinian Archaeology*, Ann Arbor 1984, 163.
37. R. D. EVELY, *supra n.* 28.
38. Cf. B. ROTHENBERG, Bar-shaped copper ingots from Early Bronze IV settlements in the Negev, *IAMS* 17, June 1991, 3-4, fig. 2, A. ΜΙΧΑΗΛΙΔΟΥ, *Τα μετάλλινα ευρήματα από τη Δυτική Οικία* (υπό έκδοση).
39. M. J. BECKER, *supra* n. 36, 125.
40. See J. V. CANBY, Early Bronze Trinket Moulds, *Iraq* XXVII, 1965, 53-54.

king of Uruk, the conquerors took as plunder not only the precious metals but also the moulds for casting metals[41]. The mould of Akrotiri comes from the upper room 5 of the West House. It was possibly stored in one of the cupboards and was left there. Anyway, we should consider the possibility that moulds for jewellery (or even for tools) had been taken away as part of the craftsmen's personal belongings.

Narrow strips of bronze (Pl. 24a) found at Akrotiri could have been used as bands bound around a mould, especially if future analysis proves them to be of copper[42], which would add both flexibility and the highest possible melting point[43]. But they were not found in association with moulds and could easily have been used for other things too.

To produce sheet metal (of which the vessels were made) several of the hammerstones found at Akrotiri could be used (among other functions), those with flat faces for smoothing the metal and others with rounded face for chasing, while beating it on an anvil[44]. In Egyptian representations, the anvil used was made of stone placed on a wooden block to absorb the hammering[45]. A stone «anvil» (?) was found at Akrotiri[46] but in secondary use, incorporated in the exterior wall of building Gamma, and stone anvils are also recorded from the same building[47]. Hammerstones were found in basement room 4 of the West House, where Marinatos thought that cuppelation was practised[48]; but chemical analysis proved that the block thought to be of «cerussite» was in fact emery and the white substance in the tripod vessels was lime[49]. When room Gamma 1, in which many hammerstones have been found, is excavated, we will be in a position to say more on this other candidate metalworking workshop[50].

With regard to the raw meterials, metalliferous ores in the Cyclades are known from literary sources, modern exploitation and artifact analysis and signs of prehistoric mining activity have been found at least in Siphnos (silver and lead) and Kythnos (copper)[51]. It seems that local sources of metals were

41. C. Zaccagnini, Patterns of Mobility among Ancient Near Eastern Craftsmen, *JNES* 42, 1983, 257.
42. As in H. Catling - R. Jones, *supra* n. 20, 61.
43. R. D. G. Evely, *supra* n. 28.
44. Cf. Egyptian representations in B. Schiele, *supra* n. 32, 28-31.
45. *Ibid.* figs 28-29.
46. *THERA III*, 176, pls 213-214.
47. *Ibid.* 44.
48. *THERA VI*, 22.
49. Χ. Παπατρεχας - Β. Περδικατσης, *Πετρολογική μελέτη δειγμάτων ηφαιστειακών πετρωμάτων από τον αρχαιολογικό χώρο Ακρωτηρίου Σαντορίνης*, Έκθεση ΙΓΜΕ 1987.
50. *THERA III*, 47.
51. R. Barber *supra* n. 22, 144. See also C. Doumas, *supra* n. 23, 113, Z. A. Stos-Gale and N. H. Gale, The Role of Thera in the Bronze Age Trade in Metals, in D. Hardy et al (eds), *Thera and the Aegean World III*, 1990, vol. 1, 74-75.

exploited as early as the EBA. As far as Thera is concerned, the Lead Isotope Analysis of some bronze artifacts has pointed both to the Laurion as well as to the Cypriot field for the provenance of copper[52], but there is still more work to be done on this subject. The XRD analysis of less than ten objects has shown –as expected– that copper was alloyed with tin[53]; surprisingly enough, the tripod cauldron from the West House was proved to be made only of copper[54] which is also attested in the cauldron from Phaistos and other sites[55]

The possibility of a local lead production on the island of Thera had been proposed as early as 1972 by Marinatos, in reference to a heavy grinding stone considered –through X-Ray analysis– to be cerussite; he added that «several other heavy objects found in our excavations tend to show that cerussite is a local product of the island»[56]. A doubt is expressed[57] that the speciman could be proved to be oxidized litharge, if the 1972 sample was taken only from the surface of the piece. Two pieces of lead, found in the West House –may be parts of bun cakes– were proved by XRD to be secondary Pb ores and not litharge[58]. There are currently two views on the lead provenance for the artifacts from Akrotiri. The first, based on Lead Isotope Analysis, supports a Laurion source[59], the second proposes a local source[60]. The Oxford team is sure that there are samples of litharge at Akrotiri suggesting silver smelting activity for Thera[61], though one of the specimens, considered as litharge, is characterised by Bassiakos et al. as a secondary Pb-ore[62]. Two large pieces of lead have been found in the settlement at Akrotiri[63]. The second one was analysed and proved to be secondary Pb-ore[64] and «the ore pieces found at Akrotiri appear geochemically similar to the Pb-ores of Athinios mines»[65].

52. Z.A. Stos-Gale, supra, fig. 16.
53. For the possible tin sources of the period there is a vast bibliography, see for instance in the *Journal of Mediterranean Archaeology* 5/1, 1992, 77-103.
54. *THERA VI* pl. 62β, E. Μαγκου, Παράρτημα Ι στο Α. Μιχαηλιδου, *Τα μετάλλινα ευρήματα από τη Δυτική Οικία* (υπό έκδοση).
55. H. Matthaeus, *supra* n. 12, 102.
56. *THERA V*, 35.
57. Z. A. Stos-Gale, *supra* n. 51, 85.
58. Y. Bassiakos, V. Kilikoglou, M. Vassilaki-Grimani, A. P. Grimanis, Provenance Studies of Theran Lead, in D. Hardy et al. (eds), *Thera and the Aegean World III*, 1990, vol. 2. 339, Table 1, SN 7.
59. Z. A. Stos-Gale, *supra* n. 51, 86.
60. Y. Bassiakos, *supra* n. 58, 344.
61. Z. A. Stos-Gale, *supra* n. 51, 85.
62. Y. Bassiakos, *supra* n. 58, Table 1, SN 6.
63. Cf. *THERA IV*, 38, for the first one.
64. Y. Bassiakos, *supra* n. 58, Table 1, SN 5.
65. *Ibid* 344.

The suggestion for local sources brings up the question whether minerals exposed today in the caldera rim, were accesssible prior to the Minoan eruption[66]. According to recent theories on the pre-eruption landscape, suporting the view of the pre-existence for the caldera, it seems that certain minerals –e.g. azurite, malachite, lead– located near the caldera, could have been accessible to the inhabitants of the island[67].

Some stone tools found in the settlement of Akrotiri (Pl. 25a, b) perhaps point towards the mining activities of that period. They are stone hammers of various size with one or two central grooves, convincingly interpreted –the big ones– as having been used for demolishing dangerous walls during clearing activities after the earthquakes and before the final abandonment of the City[68]. As they were found among the ruins, sometimes along with stone anchors, they could be there in secondary use, having been transported like the anchors from elsewhere, only to serve the special need which arose. They closely resemble the «grooved hammer stones» found in mines and for that reason designated as mining tools[69]. Interesting is the comparison with the Bronze Age waisted stone maul, used in mining copper, exhibided in the Ashmolean Museum (Pl 26b) coming from Alderley Edge, Cheshire[70], as well as with the stone serving as an ore-crushing tool, in the London Museum of Mankind (Pl. 26a), comming from Zambia and retaining the fibres on it.

SUBJECT 3: Metalworking in the Late Cycladic Society at Akrotiri

Since we are not dealing with early stages of metallurgy, a division of labour between the miner, the smelter and the smith, may be expected[71] and indeed smiths are mentioned later, in the Linear B tablets, where they seem to be attached to the palace authorities, regardless of their actual place of work. In ancient Egypt there were no independent craftsmen with their own workshops, and their job was so heavy, that a father recomended his son to

66. W. L. Friedrich - C. Doumas, Was There Local Access to Certain Ores/Minerals for the Theran People before the Minoan Eruption? An Addendum, in D. Hardy et al. (eds). *Thera and the Aegean World III*, 1990, vol. 1, 502-503.
67. *Ibid*, 502, and fig. 1.
68. C. Doumas, Late Bronze Age Engineering in the Aegean, *AAA* VII, 1974, 365-370.
69. R.F. Tylecote *supra* n. 26, 56, J. Pickin, Stone Tools and Early Metal Mining in England and Wales, in *P.* and S. Crew (eds), *Early Mining in the British Isles*, 1990, 39 ff.
70. Sir J. Evans, *The Ancient Stone Implements, Weapons and Ornaments of Great Britain*, London 1897, 234-235. I am indebted to Dr A. Sherrat, Keeper of the Ashmolean Museum, for the above quotation and for providing me with the picture of the object.
71. Tylecote's view in R. F. Tylecote, *supra* n. 26.

study more, in order to become an official, instead of having to work hard as a craftsman all his life[72]. What could the status of the smiths be at Akrotiri? We have not yet run into an «atelier de fondeur» like the one in quartier Mu at Mallia[73], though the mould stored in the upper room of the West House belonged probably to one of its occupants. The composition, nature and social status of the Minoan labour force in general, is discussed by Evely[74]. Branigan has generally divided the craftsmen into three cetegories: full-time itinerants, full-time residents and part-time residents[75]. For the first category we have the evidence provided by the Cape-Gelidonya ship-wreck[76], of a later date, but as the variety of matrices on stone moulds of a much earlier date show[77], there is no reason not to regard the possibility of itinerant metalworkers, especially for producing jewellery and high-prized artillery; for simple «domestic» or «craft» tools, resident smiths would be probable, and their time of occupation would rely on the ability or not of the Akrotiri society to support them. As is mentioned elsewhere[78], full-time smiths are found where there is an élite to support them. It is accepted though, that while palaces supported full-time craftsmen, craft-specialization was not necessarily confined to the palatial centres[79]. A great deal of craft goods were produced in the settlements and it is probable that at the time of Linear A script their produce, though under the influence of the palaces (in provision of «exotic» raw materials perhaps or in demand of high-skill artifacts?) was not necessarily under direct palatial control[80]. For the Cycladic island of Kea, Georgiou[81] supports the idea of part-time specialists, on the grounds that no industrial quarter was found in the town of Aghia Irini. It is obvious, that the community of LC Akrotiri could support other full-time specialists at least (whether residents or not) as showed by the

72. B. Schiebl, *supra* n. 32, 59.
73. J. C. Poursat, *Guide de Malia au temps des premiers palais. Le Quartier Mu*, Paris 1992, 14-17.
74. R. D. G. Evely, *supra* n. 28.
75. K. Branigan, Craft Specialization in Minoan Crete, in O. Krzyszkowska - L. Nixon, *Minoan Society*, Cambridge 1983, 23.
76. G. F. Bass, *Cape Gelidonya: A Bronze Age Shipwreck*, Philadelphia 1967, 163 ff.
77. J. V. Canby, *supra* n. 40.
78. By M. J. Rowlands, cited by K. Branigan, *supra* n. 75, 29.
79. E. Schofield, Evidence for Household Industries on Thera and Kea, in D. Hardy et al. (eds), *Thera and the Aegean World III*, 1990, vol. 1, 201, M. Van Effenterre, Réflexion sur l'organisation des ateliers dans la civilisation creto-mycénienne, in *Minoan society* (*supra* n. 75), 69-73.
80. Α. Μιχαηλιαου, Μετρικό σύστημα και σχέσεις παραγωγής στο Αιγαίο στην Ύστερη Εποχή του Χαλκού, *ΠΟΙΚΙΛΑ, Μελετήματα 10* (έκδοση του Κ.Ε.Ρ.Α. του Ε.Ι.Ε.) 1990, 84-85.
81. H. Georgiou, *Ayia Irini: Specialized Domestic and Industrial Pottery, KEOS VI*, 1986, 53.

quality and quantity of frescoes[82] (even in houses of average size) and for Akrotiri the term «Household Industries» has been used[83], indicated at least in the case of weaving[84]. It maybe added that painters and metalworkers fall into the élite craft specialists in Brumfiel's classification[85]. Yet their products seem to be widely consumed in the settlement of Akrotiri (though only in the case of the former, can we be sure that they were produced on the island itself, as were textiles). Textiles, metal artifacts and frescoes, are all classified as items requiring labour-intensive methods of production, for which reason they are considered as having a high level of manufacturing labour[86]. As far as acquisition labour is concerned, this could be low for woollen textiles, since shepherding is attested in Thera[87], while for the metal artifacts it depends on whether we accept local sources for some metal ores (see above). But labour investment is considered a more important factor to politicaly centralized societies then access to non-local raw materials, and so more research is needed on the general subject of craft specialization at Akrotiri, if it is to be regarded as a political activity along with its economic and artistic role[88].

CONCLUDING REMARKS

The question we addressed in this paper was the approach to the subject of metalworking in the prehistoric settlement of Akrotiri on Thera, a settlement provided with most of its original equipment in a well defined chronological horizon. The aim was not to present, one by one, all the –as yet unpublished– evidence; every piece of it first deserves proper publication. But to describe the problem is a step equally important towards its solution; we need to know where we stand before we start and to discuss the subject before we evaluate the evidence available. So, where do we stand?

Concerning Subject 1 –the products of metal technology– the idea is now that their quantity is not as small as first thought. Apart from the jewellery,

82. See DOUMAS 124-125.

83. E. SCHOFIELD, supra n. 79, also A. MICHAILIDOU, The Lead Weights from Akrotiri: The Archaeological Record, in D. HARDY (et al. (eds), *Thera and the Aegean World III*, 1990 vol. 1, 407.

84. I. TZACHILI, All Important yet Elusive: Looking for Evidence of Cloth-Making at Akrotiri, in D. HARDY *supra*, 380 ff.

85. E. M. BRUMFIEL, Elite and Utilitarian Crafts in the Aztec State in E. M. BRUMFIEL - T. K. EARLE (eds), *Specialization, Exchange and Complex Societies*, Cambridge 1987, 117, note 1.

86. P. PEREGRINE, Some Political Aspects of Craft Specialization, *World Archaeology* 23, 1, June 1991, 6.

87. C. S. GABLE, The Bronze Age Animal Economy from Akrotiri: a Preliminary Analysis, in C. DOUMAS (ed), *Thera and the Aegean World I*, 1978, 745-753 and C. TRANTALIDOU, Animals and human diet in the Prehistoric Aegean, in D. HARDY *supra* n. 83, vol. 2. 399.

88. P. PEREGRINE, *supra* n. 86, 8.

that must have existed if we are to rely on the frescoes' depictions, quite a variety of everyday implements was left behind. A preliminary study of the contents of 5 households of similar standard, showed that in each, lead balance weights, bronze tools, bronze vessels, a few metal objects for personal use and some relics of bronze fittings, were part of their equipment. To go further in this direction we need to concentrate on special categories of objects (provided that we have decided on their definition first) and for each category to investigate its context and distribution in the settlement. For example, it is very helpful that in some cases we know the context of whole sets of lead weights, so that we can hope for further conclusions beyond the mere metrological results[89].

On Subject 2, there is direct evidence of metalworking activity on site: the fragment of a copper melting crucible with metal waste inside it, the two clay tuyères for blow pipes, the steatite two-faced mould for lead objects (most probably bar ingots of triangular section), hammer stones for working sheet metal and other stone implements coming from the –yet not fully excavated– Sector Gamma. Proceeding to the subject of metallurgy, the great probability that certain minerals located near the caldera were in fact accessible to the prehistoric inhabitants, as well as the similarity of secondary Pb – ores from the Akrotiri excavations to samples from the Athinios mines, point towards the possibility of metallurgical activities on the island itself. To this direction, we reached a negative answer for the pieces having been recorded by the first excavators as smelting slags and now considered as material ejected by the voclano. On the contrary, a possitive answer may be furnished by further research on the stone grooved hammers from Akrotiri. There are three possibilities: a) they have nothing to do with mining and ore – crushing activities, b) they are mining tools fabricated from local volcanic material to be exported to sites outside the island, in that case not necessarily indicating any exploitation of Theran mines, c) they are tools of miners working on this island. For the first possibility, we have the unusual element of the double groove, which may be explained by the need for safer attachment of ropes to heavier hammers, but why use heavier hammers? For the second possibility we have the information that at Siphnos the crushing stones of trachyte and other non-indigenous volcanic rock, were imported[90]. But have double-grooved hammer stones been recorded outside Thera? Coming to the third possibility, it has been suggested with regard to other sites, that the smaller stone mining hammers,

89. A. Μιχαηλαιου, *supra* n. 80.

90. G. Weisberger, Towards a history of copper mining in Cyprus and the Near East: Possibilities of Mining Archaeology, in J. Muhly, R. Maddin, V. Karageorghis (eds), *Early Metallurgy in Cyprus, 4.000 - 500 B.C.*, Nicosia 1982, 27.

with a single central groove, could be used «by swinging them at the rock face of the mine, the groove allowing the attachment of a thong or rope held in the hand»[91] and «those grooved hammers left identifiable traces on the walls of the mines (shallow rounded depressions)»[92]. It has also been suggested that «the largest stones (above 4 kg) were probably swung from a length of rope held between two people or possibly from a wooden structure, as has been found underground at Zawar in India»[93]. We must notice the presence of both one– and two– grooved stones in Akrotiri[94] (Pl. 25a, b). It is true that some of the two-grooved hammers (so called because of the wear and tear on the two edges) are as heavy as 13 kg. but, if properly suspended, the weight would achieve heavier strokes. Doumas was right in explaining that the function of the two or four cavities (inside the parallel grooves) «was to prevent something from sliding off, most probably ropes which were fastened round the grooves»[95] (cf. Pl. 26a) and he suggested a wooden construction[96] which is very near (and a better idea) to the construction used experimentaly in Britain, where a large hammer cradled from a rope sling gave powerful blows to the vertical face of the rock[97]. So was the «machine» first invented for the mines and the idea (and the hammers) transmitted to the ruined settlement because of the need for a similar action? The study of the stone tools by the experts may bring the answer.

Regarding Subject 3, the Akrotiri community could certainly support full-time smiths, but in order to say more about their status, one needs to extent the analysis to the general subject of craft specialization and exchange, a subject far beyond the scope of this article.

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91. R. F. TYLECOTE, *supra* n. 26, 56 and fig. 2.8.
92. G. WEISBERGER, *supra* n. 90, 26.
93. B. CRADDOCK, The Experimental Hafting of Stone Mining Hammers, in P. and S. CREW, *Early Mining in the British Isles*, 1990, 58.
94. C. DOUMAS, *supra* note 68, 367, fig. 3.
95. *Ibid*, 366.
96. *Ibid*, fig. 6.
97. A. LEWIS, Firesetting Experiments on the Great Orme, 1989, in P. and S. CREW, *Early Mining in the British Isles*, 1990, 55, 56.

ΠΕΡΙΛΗΨΗ

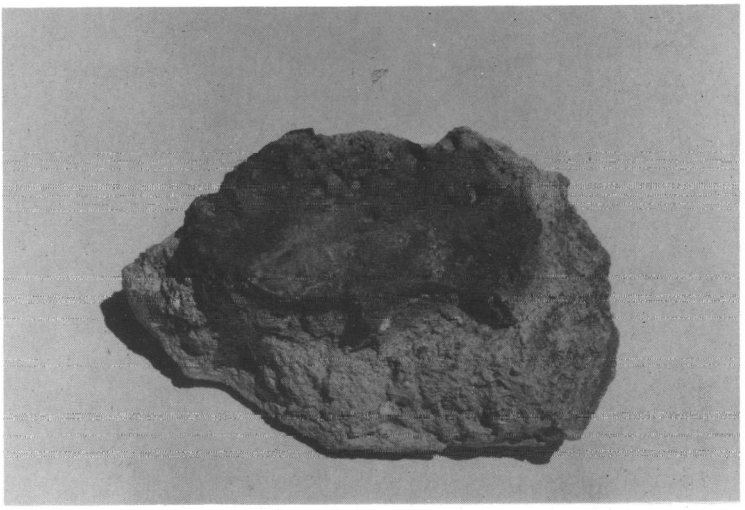
ΑΝΑΖΗΤΩΝΤΑΣ ΜΕΤΑΛΛΟΤΕΧΝΙΚΕΣ ΔΡΑΣΤΗΡΙΟΤΗΤΕΣ ΣΕ ΕΝΑΝ ΟΙΚΙΣΜΟ: Η ΠΕΡΙΠΤΩΣΗ ΤΟΥ ΑΚΡΩΤΗΡΙΟΥ ΘΗΡΑΣ.

Ο σκοπός του άρθρου είναι η κριτική αντιμετώπιση των ερωτημάτων που ανακύπτουν όταν ο αρχαιολόγος ερευνά τη δραστηριότητα της μεταλλοτεχνίας (ίσως και της μεταλλουργίας) στον προϊστορικό οικισμό του Ακρωτηρίου Θήρας. Συγκεντρώνονται, για αυτό το λόγο, επιχειρήματα και ευρήματα των παλαιότερων ανασκαφέων, αναγνωρίσεις που έγιναν εκ των υστέρων μέσα στις αποθήκες, πορίσματα από τις μελέτες θετικών επιστημόνων των τελευταίων χρόνων και απόψεις αρχαιολόγων από άλλες ανασκαφικές θέσεις. Το πρώτο θέμα είναι η ποσότητα των προϊόντων της μεταλλοτεχνίας και η κατανομή τους στο χώρο. Το προκαταρκτικό συμπέρασμα αυτής της σύντομης επισκόπησης είναι ότι η ποσότητα και κυρίως η ποικιλία των αντικειμένων που οι κάτοικοι άφησαν πίσω τους, όταν εγκατέλειψαν τον οικισμό είναι υπολογίσιμη. Και οι πρώτες συγκρίσεις ανάμεσα στα «νοικοκυριά» του οικισμού δίνουν μία τυπική εικόνα για τον οικιακό εξοπλισμό από μετάλλινα αντικείμενα. Το δεύτερο ερώτημα αφορά στην επί τόπου άσκηση της μεταλλοτεχνίας στον οικισμό, και δίδεται το υλικό που μπορεί να τεκμηριώσει μία θετική απάντηση. Προχωρώντας στο θέμα της μεταλλουργίας, αναφέρονται οι έρευνες που καταλήγουν στην πιθανότητα για εντόπιες πηγές μετάλλων και οι έρευνες που την αντικρούουν. Καθώς οι τελευταίες μελέτες για το προεκρηξιακό τοπίο του νησιού δεν αποκλείουν τη δυνατότητα πρόσβασης σε ορυχεία του νησιού για την εποχή αυτή, διατυπώνεται η υπόθεση ότι ορισμένα λίθινα εργαλεία που βρέθηκαν στον οικισμό είναι εργαλεία μεταλλωρύχων σε δεύτερη χρήση. Αυτή η υπόθεση εργασίας προκύπτει από ευρήματα άλλων περιοχών, από εθνολογικά παράλληλα και από πορίσματα της πειραματικής αρχαιολογίας.

a.

b.

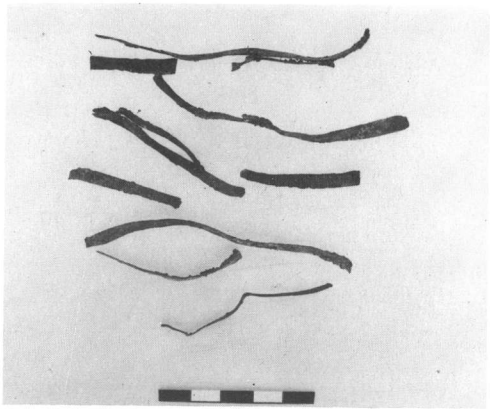
a. *West House, upper floor, room 6: a group of lead weights found among the fallen conical cups, near the east wall.* b. *Sector Beta, room 7: bronze dagger as found.*



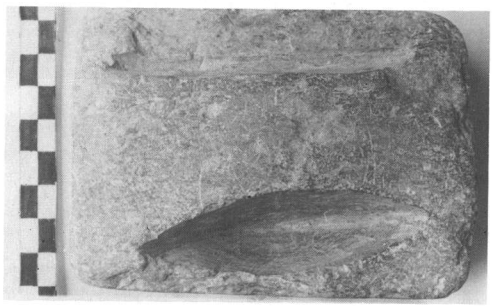
a.

b.

a. *Fragment of a crucible with some metal waste inside (L. 7 cm).* b. *One of the two tuyères.*



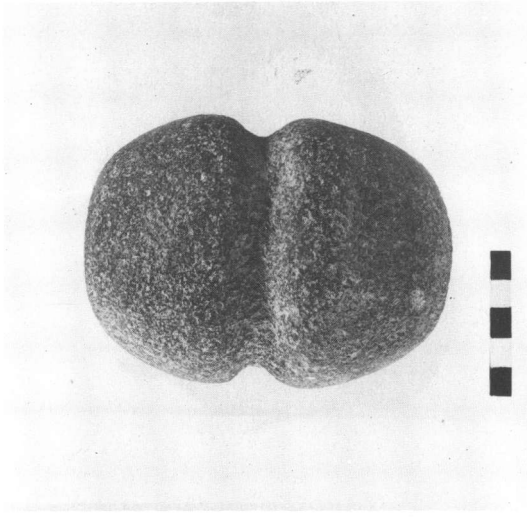
a.



b.

c.

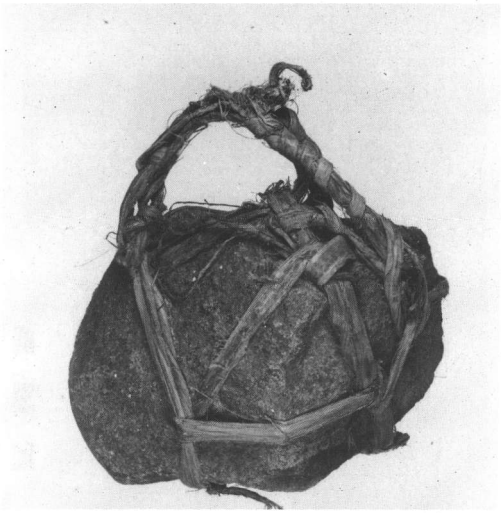
a. *Some narrow strips of bronze.* b. *One of the two faces of the steatite mould.* c. *A piece of material ejected by the volcano and wrongly recorded as slag.*



a.

b.

a, b. *Stone grooved hammers from Akrotiri (L. 13 cm and 31,5 cm).*



a.

b.

a. *Stone ore-crushing tool from Zambia (copyright: British Museum, London).* b. *Bronze Age waisted maul from Alderley Edge, Cheshire (L. 20 cm; courtesy of the Ashmolean Museum, Oxford).*